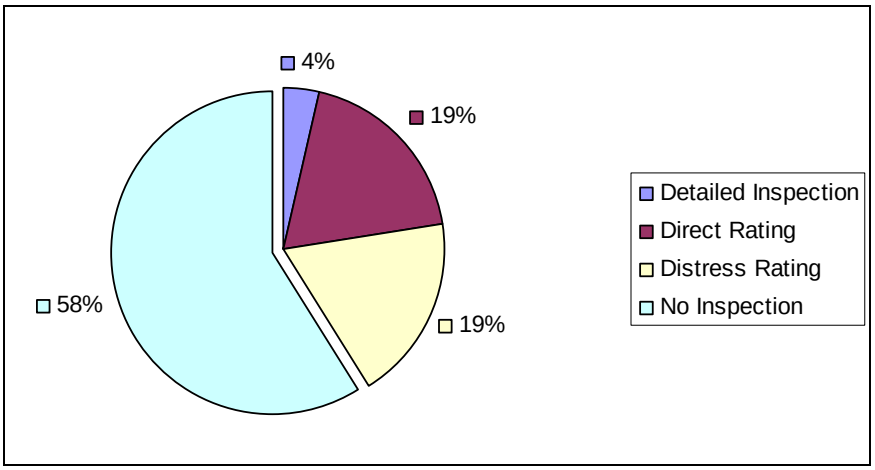
Knowledge-Based Inspection Capabilities

ERDC/CERL Technical Note TN-06-1 **January 2006**

Overview. Effective facility infrastructure inspections are essential for a successful asset management program. They provide vital decision support information about current condition, future performance and reliability, and capital repair/restoration requirements. Some infrastructure assets are inspected using strictly regimented procedures at a specified frequency, but that approach is cost-prohibitive for most infrastructure domains, especially where failure does not present a compelling safety hazard. Abandoning certain inspection programs to reduce costs is not a viable alternative, however, because that could degrade real property investments, soldier quality of life, and mission-readiness. The best way to reduce inspection costs while effectively managing risk would be a *knowledge-based process* that focuses technical attention and resources on the most crucial aspects of infrastructure life-cycle and mission-criticality.



Knowledge-based inspection cuts costs because it requires only minimal detailed inspection and does not sacrifice quality.

Infrastructure at risk. Real property managers continue to struggle with shrinking maintenance and repair budgets as their facilities rapidly age and deteriorate. A common response to these pressures is to curtail inspection and preventive maintenance programs, and allocate resources to critical short-term repairs as needed. This *ad hoc* approach forces managers to react to breakdowns and system failures at the most inopportune and expensive time — after a capability or service is interrupted. Effective planning, programming, and budgeting becomes almost impossible, with facility performance following condition in a downward spiral.

Mission-focused asset management. Facility inspections are critical to effective infrastructure life-cycle management for many reasons. They provide the means to (1) quantify condition, (2) track condition history and identify trends, (3) determine future work requirements and scope, (4) to assure future performance and reliability, and (5) estimate the remaining service life until capital renewal is justified. No single inspection approach serves all these purposes equally well. The most effective and cost-efficient inspection program will focus on mission-critical factors in the context of the specific facility's life cycle. Starting with reliable knowledge about a facility inventory, managers can specifically adapt inspection methods and scope to an individual facility's mission criticality, the degree of risk tolerated for that mission, and the facility's known life-cycle history. In particular, inspection frequency and level of detail can be assigned on the basis of the expected condition state as deduced by its time

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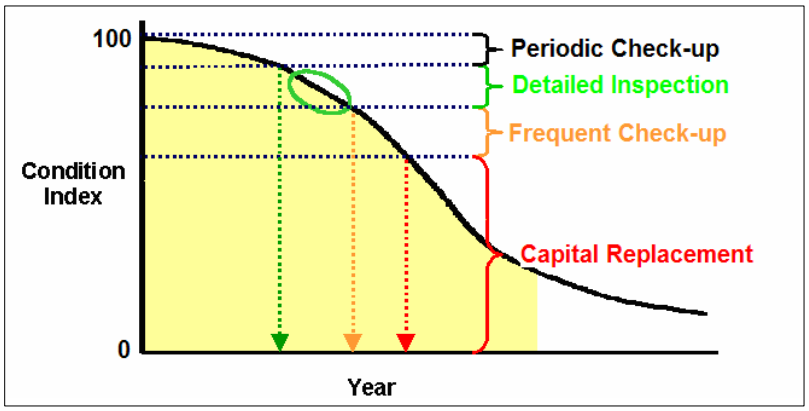
in service and trends identified in previous inspection data. In other words, by focusing resources on minimizing risk to mission support, a knowledge-based approach can eliminate costly inspection tasks that add little value.

The classical infrastructure deterioration curve shown below illustrates how condition degradation accelerates over time. Overall component condition loss begins slowly, but later it accelerates dramatically as the simultaneous degradation of its own subcomponents lead to compound modes of deterioration.



Infrastructure deterioration graph showing inspection alternatives during life cycle.

A knowledge-based asset management program can identify the most mission-critical components and ensure that they are maintained at a condition above the required performance threshold.

The infrastructure deterioration graph also shows a relationship between facility life cycle and inspection requirements. In the early portion of the life cycle, component condition is expected to be good so only periodic check-ups are needed. Further into its life cycle, detailed assessments are necessary to track deterioration as the component approaches its minimum performance threshold. Finally, as the component approaches the end of its service life, frequent check-ups are warranted only monitor for an impending total failure. Inspection scheduling and level of detail are assigned on the basis of the component's age, previous inspection results, and importance to mission.

Benefits of knowledge-based inspection. This inspection approach improves on a traditional program of rigidly scheduled comprehensive inspections. By eliminating infrastructure inspection tasks that contribute little to risk management and mitigation, the knowledge-based approach better matches resource investments to mission requirements. The criteria considered in developing appropriate inspection schedules include facility importance to mission, component criticality, time in service, remaining service life, current condition, deterioration rate, performance requirements, and reliability thresholds. A knowledge-based condition assessment plan is critical to an effective and affordable asset management program. Knowledge-based inspection practices will enable facility managers to match inspection frequency and level of detail to mission objectives and performance requirements. The result will be higher asset reliability, more affordable infrastructure life-cycle management, and improved mission effectiveness. ERDC-CERL has applied for a U.S. patent on a Knowledge-Based Inspection Process.

Points of Contact:

Lance R. Marrano, Civil Engineer
ERDC-CERL
lance.r.marrano@erdc.usace.army.mil
217-373-4465

Michael N. Grussing, Civil Engineer
ERDC-CERL
michael.n.grussing@erdc.usace.army.mil
217-398-5307

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